Cooksville Creek Flood Evaluation Master Plan EA

Final Report

A report prepared for:

The City of Mississauga

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EXECUTIVE SUMMARY

Introduction

The Cooksville Creek watershed is an urban watershed located entirely within the City of Mississauga. The watershed drains an area of approximately 33.9 Km^2 (3,390 ha) outletting to Lake Ontario. The watershed has been under increasing urban development pressure since the 1940's, moving from a predominant agricultural land use with woodlots and natural creek corridor in the forties to a combination of residential and industrial/commercial land use at present time (60% residential, 34% industrial/commercial, 6% open space).

Drainage infrastructure within the Cooksville Creek watershed has been designed to quickly and efficiently convey flows from the table lands to the receiving stream. More specifically, stormwater and flood management within the Cooksville Creek watershed has hinged upon a storm sewer system spanning across the watershed and three stormwater management facilities used as detention basins to store stormwater runoff and slowly release it to the receiving waterways.

Past experience with riverine issues across the Cooksville Creek watershed suggests that it is prudent to pursue a modern, implementable approach that attempts to mitigate riverine flooding. In order to address a progressive vision for looking at flood control for environmental and socio-economic purposes, this study proposes a combination of traditional measures that have been historically proposed to manage flood issues within the Cooksville Creek watershed (EWRG, 2002) and innovative flood control approaches that not only address flooding issues but also consider the management of other environmental features and functions in the watershed such as water quality and stream erosion. The study also presents an implementation strategy to assure that the solutions proposed are tangible and implementable.

This study is a Master Plan that is carried out under Approach 1 of the Municipal Class Environmental Assessment, and is subject to the requirements of the Environmental Assessment Act. Public meetings, together with a series of formal and informal meetings were held with stakeholders including the City of Mississauga, Credit Valley Conservation and local residents.

Study Objectives

The objectives of the study are as follows:

- Primary objective:
  - Reduce the occurrence of riverine flooding for dwellings and properties adjacent to Cooksville Creek
- Secondary objectives:
  - Reduce extent and frequency of erosion;
  - Improve water quality conditions within Cooksville Creek;

- Improve aquatic habitat conditions

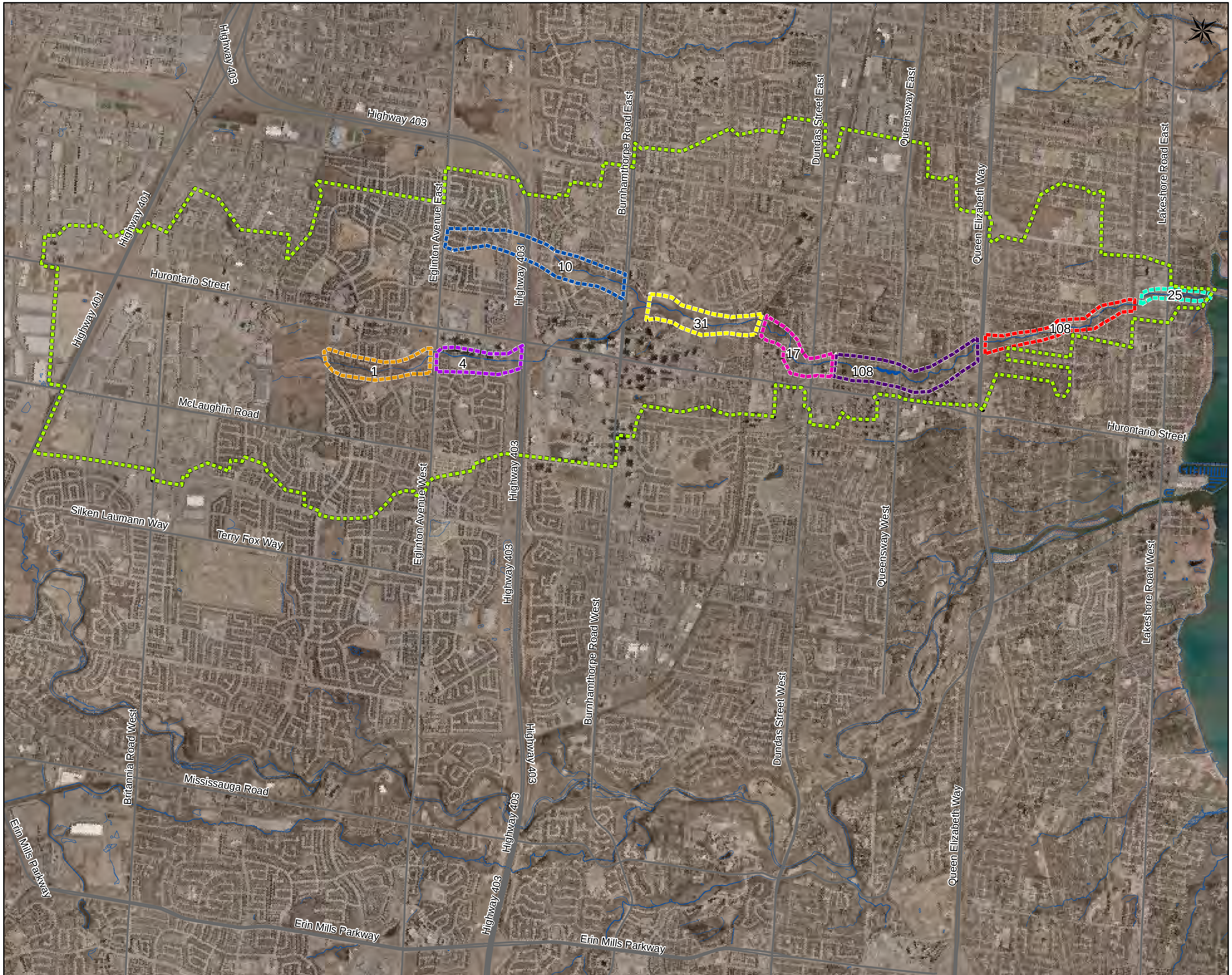
Phase 1 – Problem and Opportunity Identification

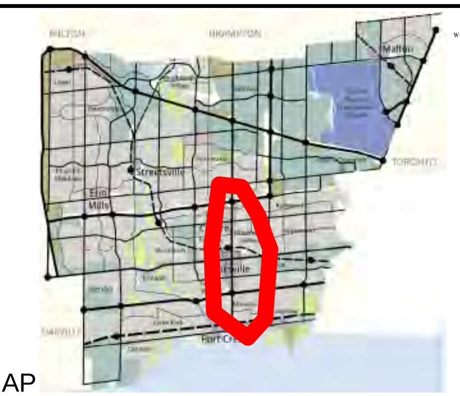
Based on the requirements of the Environment Assessment process stipulated by the Municipal Class Environmental Assessment (MEA, 2007), there are identified problems and/or opportunities that need to be addressed in the study area. The problems identified in this study are divided into primary problems and secondary problems.

Primary problem

As a result of the urban character of the Cooksville Creek watershed, the watershed exhibits a flashy hydrologic response typical of highly urbanized watersheds developed without the benefits of updated stormwater management infrastructure. Flooding and drainage issues exist within the watershed in areas where development has reduced channel conveyance and restricted floodplain capacity, and as a result caused backwaters to flood upstream reaches. According to the Cooksville Creek Flood Remediation Plan (EWRG, 2002), approximately 304 buildings can be inundated in the middle and lower part of the watershed for the regulatory flood (i.e. Hazel Storm) and 119 buildings for the 100-year flood. Recent storms occurring in the watershed (August 4, 2009 storm) had caused flood damages that impacted buildings, municipal infrastructure, pedestrian bridges and channel protection measures along Cooksville Creek (EWRG, 2010).In terms of location within the watershed, the Cooksville Creek Flood Remediation Plan (EWRG, 2002) notes that the buildings impacted by flooding are classified as follows (**Figure ES.1**):

- From CNR to the QEW, approximately 108 buildings could potentially be flooded for the regulatory storm. The majority of the buildings could be flooded because of the CNR crossing low capacity (130 m^3/s compared to Regional Flow of 295 m^3/s).
- From QEW to King Street East, 108 buildings could potentially be flooded due to QEW crossing low capacity (110 m^3/s compared to Regional Flow of 295 m^3/s).
- From the CPR to Central Parkway East, where CPR crossing has a capacity of 125 m^3/s compared to 250 m^3/s for the Regional Flow.





KEY MAP

LEGEND:

Streams

Subwatershed Boundary

Properties Susceptible to Flooding During Regulatory Storm

Location

- Burnhamthorpe Road East to Eglinton Avenue East
- CNR to QEW
- CPR To Mississauga Valley Boulevard (North)
- Eglinton Avenue West to Matheson Boulevard West
- Highway 403 to Eglinton Avenue East
- King Street East to CPR
- Lake Ontario to CNR
- QEW to King Street East

NOTES:

Base Mapping was provided by City of Mississauga

0 0.5 1 2 Kilometers

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COOKSVILLE CREEK FLOOD EVALUATION MASTER PLAN EA

No. of Properties Susceptible to Floodling During Regulatory Storm

FIGURE No. ES.1

DATE: May 2012

Secondary problems

Secondary problems within the Cooksville Creek watershed are: erosion and water quality degradation. Erosion along Cooksville Creek is manifested by the following:

- Downward erosion of the channel into the underlying shale bedrock
- Channelization of Cooksville Creek has resulted in a loss of the historical meander pattern and associated pools and riffles
- Extensive failure of bank and bed protection

Concerning the status of surface water quality in the watershed, previous reports (CVC, 2010) notes that surface water has high levels of E coli and chloride. Water temperatures do not comply with the Provincial standards for cold water habitat. Under dry weather conditions, concentrations for nutrients and metals meet guidelines. Wet weather concentrations/loadings are significantly high for nutrients and metals and exceed guidelines. Fish habitat issues include water temperatures exceeding 26°C and unsuitable substrate for spawning needs.

Opportunities

The opportunities identified for this study include the following:

- Alleviate riverine flooding for all areas up to the 100 year flow and possibly reduce flooding extent for the Regional flow
- Improve water quality
- Reduce ongoing erosion problems
- Improve habitat for aquatic species

Phase 2 – Evaluation of Alternative Solutions

The alternative solutions that were initially developed to address the study objectives and associated issues were broadly categorized as follows:

Traditional alternatives

- Watercourse capacity upgrade: increasing the capacity of the existing watercourse may reduce flood levels.
- Crossing capacity upgrade: increasing the capacity of existing culverts or bridges may reduce water levels.
- Dykes/Berms: dykes or berms are built adjacent to dwellings in order to contain flows within the floodplain
- Flood proofing: Landowners can floodproof buildings by sealing or filling in openings which are susceptible

- Land acquisition: Flood susceptible properties could be purchased by the City or Credit Valley Conservation and then removed.

Non-Traditional alternatives

- Storage in Upstream locations: storage in upstream lands within parks or vacant properties could be used to reduce flood levels in Cooksville Creek
- Source control measures: implemented on private property, include roof downspout disconnection, use of rain barrels, pervious driveways and rain gardens
- In-channel storage: storage within Cooksville Creek could be used to reduce flood levels
- Conveyance control measures: implemented within the municipal right-of-way include bioretention units, or perforated pipes. The measures encourage infiltration or evapotranspiration, thereby reducing runoff and flood levels.
- Tunnel: construction of a tunnel, which would divert flows above levels which cause flooding could be considered.

The evaluation of the two sets of alternative solutions used a two-fold approach:

- First evaluation level: provided a general description of each potential alternative and evaluated each alternative based on the following categories of criteria:
    - Natural environment
    - Economic
    - Social/Cultural
    - Implementation

  The result of the first evaluation level was that a set of alternative solutions was brought forward based on their effectiveness in addressing the assessment criteria.

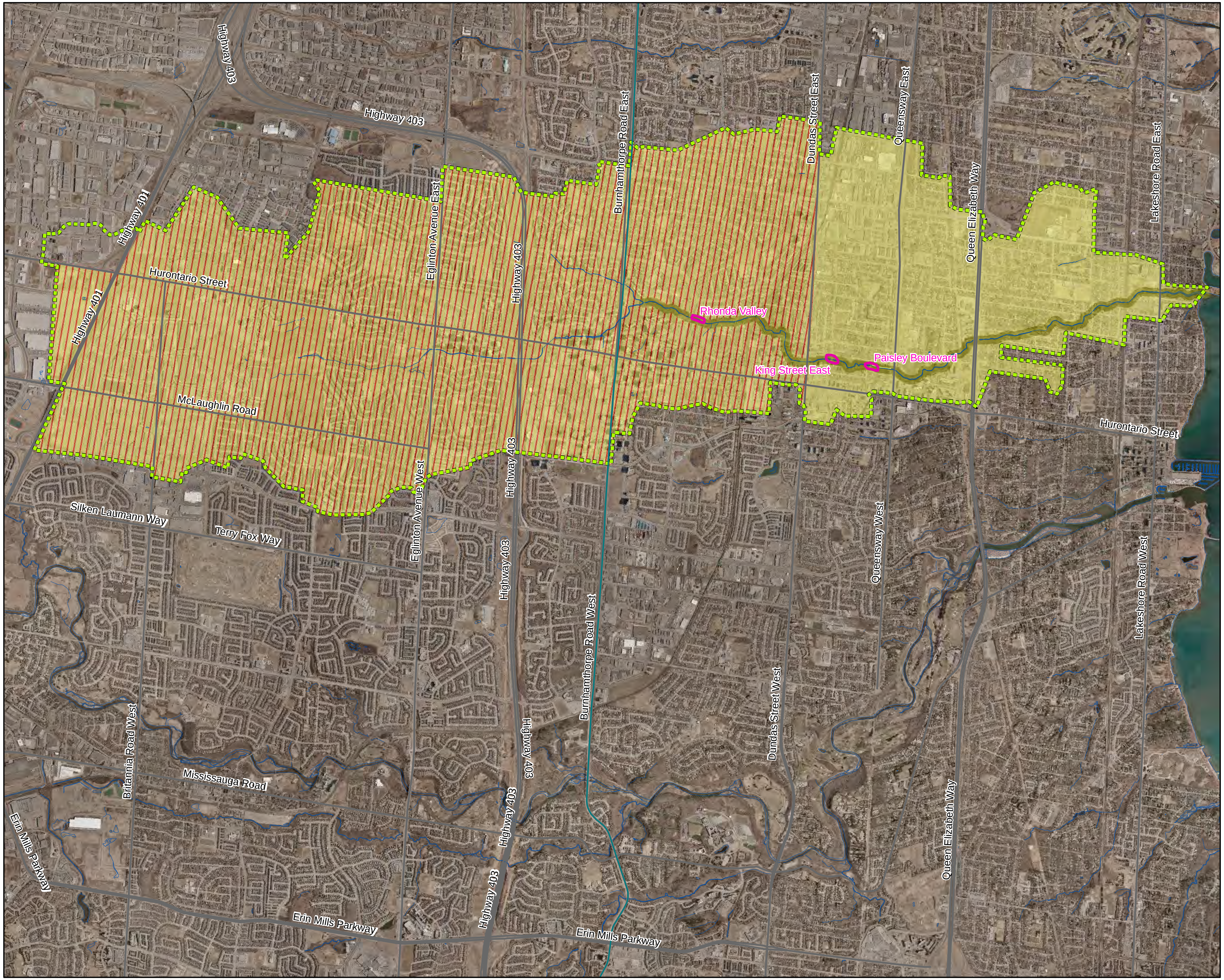
- Second evaluation level: carried out a technical assessment of the alternatives which have been brought forward in order to establish a practical plan.

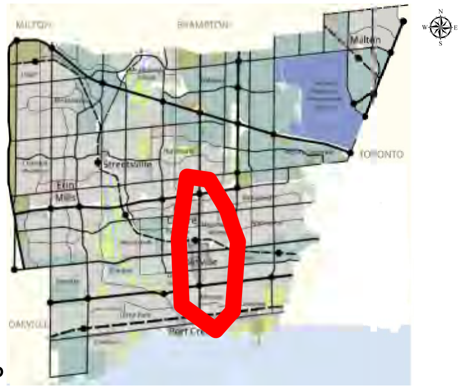
Selection of the Preferred Alternative

The set of alternative solutions that scored highest in the first evaluation level is called: the Recommended Plan. The Recommended Plan is illustrated in **Figure ES.2**, and it includes the following solutions:

- Flood storage in the upstream locations to reduce flows within Cooksville Creek to acceptable levels
- Watercourse and channel capacity upgrades together with creation of a berm in the King Street and Paisley Road areas where homes are more susceptible.

- Construction of a berm adjacent to Cooksville Creek to protect homes along Rhonda Valley
- Implementation of source and conveyance control measures





KEY MAP

LEGEND:

Subwatershed Boundary

Controls

Channel and Watercourse Crossing Upgrade

Storage

Conveyance and Source Controls

Specific Crossing Upgrades and Berms

NOTES:

Base Mapping was provided by City of Mississauga

0 0.5 1 2 Kilometers

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COOKSVILLE CREEK FLOOD EVALUATION MASTER PLAN EA

Recommended Plan

FIGURE No. ES.2

DATE: May 2012

Implementation Strategy

The Implementation Strategy describes the activities which must be undertaken if the Recommended Plan is to be successfully implemented. In preparing the Implementation Strategy, the following points were considered:

- The Implementation Strategy must be flexible and realize that the techniques and approaches will change as the knowledge base advances;
- The Implementation Strategy must be consistent with other municipal programs, policies and standards;
- The implementation should focus on areas which have historically been hardest hit by flooding

The Implementation Strategy includes the following components, many of which are illustrated in **Table ES.1**:

- Cost (capital, operation and maintenance)
- Funding alternatives
- Policy or design standard implications
- Timeframe for implementation / Prioritization
- Expected environmental benefits
- Environmental Assessment requirements
- Prioritization
- Coordination with existing programs and projects
- Future study requirements
- Monitoring requirements

Table ES.1 Implementation Strategy

Recommended Plan component	Capital cost ($)	Funding alternatives	Policy or Design Standard Implications	Timeframe for Implementation/Prioritization	Expected Environmental Benefit	Coordination with Existing Programs and Projects	Future Study Requirements
Storage in the Upstream Locations	93,600,000	Capital Funding	• Coordination with the Community Services Department re: parks programs and policies • Purchase of two properties	Park 317 (Site # 1) : 1 – 3 Years The remainder of sites (3 – 20 Years)	• Reduction of flood frequency along Cooksville Creek • Reduction in erosion problems • Improvement in water quality and aquatic habitat	Integration with the Community Services Department Parks programs and policies	Preliminary and detailed design
Watercourse and Channel Capacity Upgrades	7,500,000	Capital Funding	Purchase of vacant lot within floodplain at Paisley Boulevard	1 – 3 Years	Reduction of flood frequency at King St. and Paisley Boulevard	• Purchase of vacant lot at Paisley • Relocation of walkway in Cooksville Park	Preliminary and detailed design
Berm Construction at Rhonda Valley	300,000	Capital Funding	None	1 – 3 Years	Reduction of flood frequency at Rhonda Valley	Confirmation of existing trail/recreational requirements	Preliminary and detailed design
Implementation of Source and Conveyance Control Program	Priced as part of the Stormwater Quality Strategy Update (Aquafor, 2011)	As shown in the Stormwater Quality Strategy Update (Aquafor, 2011)	Updating by-laws and policies to accommodate source and conveyance controls (Aquafor, 2011)	1 – 25 Years	Provide many environmental benefits due to their capacity to infiltrate, store, or increase evapotranspiration thereby reducing stormwater runoff volume and flow rate	Aquafor (2011) sets up a framework for the implementation of source and conveyance control measures	• Depends on specifics of site • Geotechnical assessment • Hydraulic conductivity test

Public Consultation

Public Consultation included separate meetings with the Task Force Committee and the public. Meetings with the Task Force Committee have covered topics that included:

- Overview of the study;
- Relationship of this study to the other ongoing studies;
- General types of works that could be undertaken within the watershed;
- Information available from members of the Task Force;
- Presentation of stream restoration alternatives.

Conclusions and Recommendations

(1) Flooding issues are dominant along Cooksville Creek, especially downstream of HWY 403 where development has taken place within the Regulatory floodplain;

(2) Flooding is exacerbated due to undersized crossings and lack of stormwater management facilities to control flooding and mitigate actual and potential flood damages;

(3) There is significant opportunity to implement traditional and non-traditional flood management measures within the Cooksville Creek watershed that would mitigate flood damages and address environmental issues such as stream erosion and water quality;

(4) The evaluation of alternatives used four sets of criteria: Natural environment, Social/Cultural, Economic, and Implementation criteria. A technical assessment was applied to alternatives that were ranked highest in the evaluation;

(5) Proposing traditional and non-traditional alternatives to mitigate floods at the watershed scale (i.e. allocation of flood storage sites in upstream locations), and at the site scale (i.e. crossing expansion, watercourse realignment, and berm construction at King Street, Paisley Boulevard and Rhonda Valley) is necessary to mitigate flood damages along Cooksville Creek;

(6) The implementation of the Recommended Plan proposed in this study to mitigate flood damages would protect areas for the 100-year storm and assist in reducing impact for the Regional storm. In addition, many environmental benefits such as sustaining stream health and stability, improving water quality and aquatic habitat would be realized;

(7) The Implementation Strategy provides an approach to allocate necessary resources for realizing the Recommended Plan.

It is recommended that the following actions are taken:

(1) That the proposed flood management measures as outlined in this document (i.e. Recommended Plan) be undertaken;

(2) That the Implementation Strategy be followed in order to apply the suggestions of the Recommended Plan;

(3) That future studies take into consideration the findings and proposals outlined in this study, especially Chapter 6 and Chapter 7.

1.0 INTRODUCTION

The Cooksville Creek watershed is a typical urban watershed with 94% of its area developed and only 6% constituting open space. The watershed area is 33.9 Km^2 with an approximate length of 15 Km and an approximate width of 2 Km. Intensive urban development along Cooksville Creek accompanied with undersized road crossings and lack of adequate stormwater management measures have led to flooding issues along Cooksville Creek including a large storm event (close to the 100-year storm) which occurred on August 4^{th}, 2009 and caused flood damage along the Creek (EWRG, 2010).

The City of Mississauga has retained Aquafor Beech Limited to conduct a flood evaluation study for Cooksville Creek. Floodline mapping for Cooksville Creek was originally completed by Kilborn Limited in 1975. Dillon Limited completed the Cooksville Creek Watershed Study in 1979. Dillon's study carried out a hydrologic assessment, and identified flooding problem areas with alternative flood control measures for the 50 and the 100-year storm flows under various development conditions. The 1975 floodline mapping for Cooksville Creek was updated in 1996 by R.V. Anderson (R.V.A, 1996).

Environmental Water Resources Group completed a study entitled Cooksville Creek Flood Remediation Plan (EWRG, 2002) which reviewed the floodline mapping done by RV Anderson (R.V.A, 1996) and proposed flood mitigation measures. EWRG (2002) showed that 304 buildings (the majority of them located downstream of Highway 403) could potentially be flooded during the Regulatory Storm. Moreover, the EWRG study proposed traditional flood management measures (e.g. enlargement of road/railway crossings, channel enlargement, flood proofing) that focused on reducing flood damage during the Regulatory Storm.

Building on previous flood assessment and remediation studies covering Cooksville Creek, the City of Mississauga has shown interest in combining current knowledge concerning flood issues in the study area with new and innovative solutions in order to alleviate and/or manage flooding-related issues on public and private properties.

This study is a flood evaluation study which has the format of a Master Plan Class EA study. The study addresses relevant urban and environmental features and functions within the Cooksville Creek Watershed in order to propose innovative flood and stormwater management measures that are holistic in coping with various environmental concerns such as water quality, erosion, flooding, and fisheries, but with special focus on flooding issues.

The study consists of the following nine (9) sections:

1. **Introductio**n
2. **Identification of Problems and Opportunities**
3. **Review of Background Documents**

4. **Review of Existing Conditions**
5. **Evaluation of Alternatives**
6. **Recommended Plan**
7. **Implementation Strategy**
8. **Public Consultation Process**
9. **Conclusions and Recommendations**

The study also contains three appendices:

- **Appendix A**: Catchment Delineation for Flood Storage Sites
- **Appendix B**: Hydrologic and Hydraulic Modeling
- **Appendix C**: Public Consultation Material

1.1 Study Objectives

The objectives of the study are as follows:

- Primary objective:
  - Reduce the occurrence of riverine flooding for dwellings and properties adjacent to Cooksville Creek
- Secondary objectives:
  - Reduce extent and frequency of erosion;
  - Improve water quality conditions within Cooksville Creek;
  - Improve aquatic habitat conditions

1.2 Municipal Class Environmental Process

The study is being completed as a Municipal Class Environmental Assessment. The Environmental Assessment Act was legislated by the Province of Ontario in 1990 to ensure that an Environmental Assessment is conducted prior to the onset of development and development related (servicing) projects. Depending on the individual project or Master Plan to be completed, there are different processes that municipalities must follow in order to meet Ontario's Environmental Assessment requirements.

Class Environmental Assessments (Class EA) are prepared for approval by the Minister of the Environment. A Class EA is an approved planning document that defines groups of projects and activities and the environmental assessment (EA) process which the proponent commits to for each project undertaking. Provided the process is followed, projects and activities included under the Class EA do not require formal review and approval under the EA act. In this fashion, the Class EA process expedites the environmental assessment of smaller recurring projects.

The Municipal Class Environmental Assessment Master Planning process to be followed in this study is illustrated in **Figure 1.1**. The process as shown in **Figure 1.1** could involve up to five phases of assessment. These phases include:

- **Phase 1**: Establish the Problem or Opportunity
- **Phase 2**: Identify and Assess Alternative Solutions to the Problem, and Select a Preferred Alternative
- **Phase 3**: Identify and Assess Alternative Design Concepts for the Preferred Solution, and Select a Preferred Design Concept.
- **Phase 4**: Prepare an Environmental Study Report
- **Phase 5**: Process with Design and Implementation.

Public and agency consultation is also an important and necessary component of the five phases.

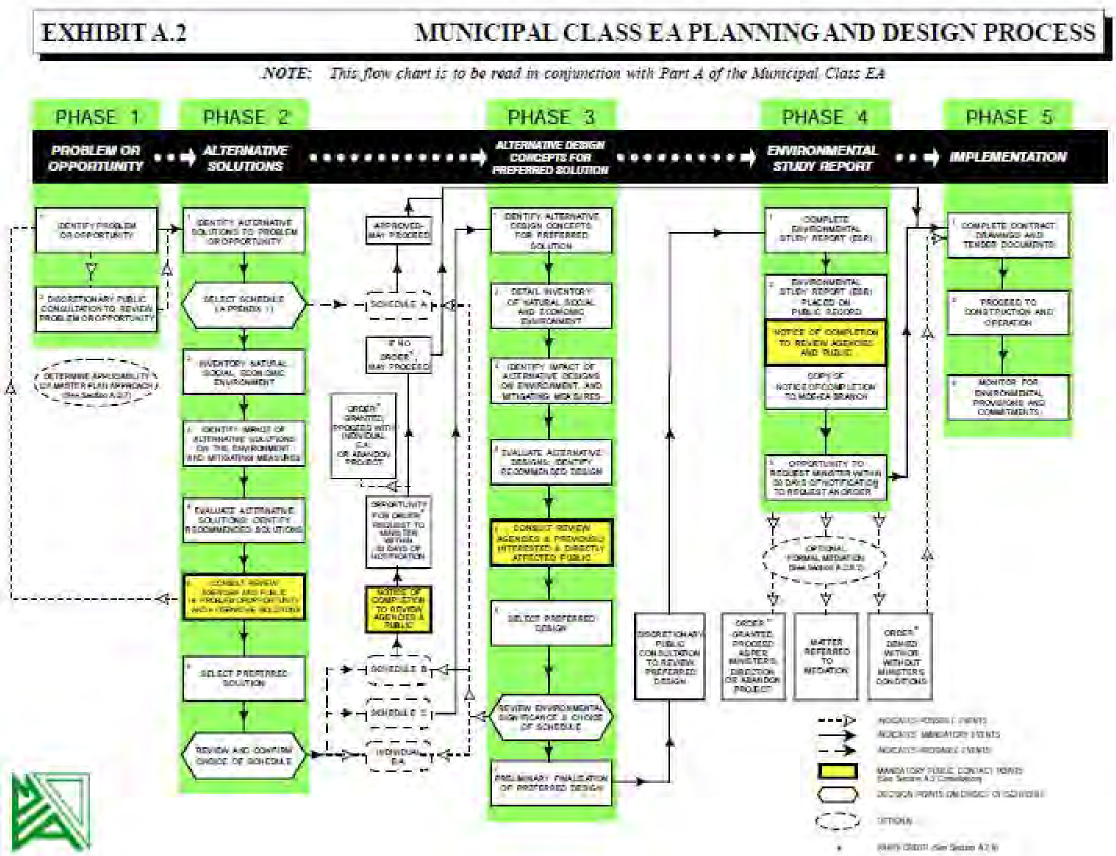


Figure 1.1 MEA Planning and Design Process (MEA, 2007)

In partial fulfillment of Ontario's Environmental Assessment requirements, a Master Plan must satisfy at least the first two phases of the Class Environmental Assessment process. Depending on the type of Master Plan to be completed, Phases 3 and 4 may also be required.

The Municipal Engineers Association's Class EA document also classifies projects as Schedules A, A+, B or C depending on their level of environmental impact and public concern. Any project identified in this Master Plan must be classified as to their level of complexity which will in turn decide which Schedule process needs to be followed.

- **Schedule 'A'** projects are generally routine maintenance and upgrade projects; they do not have the potential for significant environmental impacts or need public input. Schedule 'A' projects are pre-approved without any further public consultation.

- **Schedule 'A+'** Introduced in 2007 by the Municipal Engineers Association, these projects are pre-approved; however the public is to be advised prior to the project implementation. Per Appendix I –Project Schedules of the Municipal Class Environmental Assessment (2000, as amended in 2007), wastewater management projects that are intended to "**modify, retrofit, or improve a retention/detention facility including outfall or infiltration systems for the purposes of stormwater quality control" including "biological treatment through the establishment of constructed wetlands"** are pre-approved under Schedule A^+ of the MEA.

- **Schedule 'B'** projects have more environmental impact and do have public implications. Examples would be stormwater ponds, river crossings, expansion of water or sewage plants beyond up to their rated capacity, new or expanded outfalls and intakes, and the like. Schedule 'B' projects require completion of Phases 1 and 2 of the Class EA process.

- **Schedule 'C'** projects have the most major public and environmental impacts. Examples would be storage tanks and tunnels with disinfection, anything involving chemical treatment or expansion beyond a water or sewage plants rated capacity. Schedule 'C' projects require completion of Phases 1 through 4 of the Class EA process, before proceeding to Phase 5 implementation.

The Municipal Engineers Association's Class EA document also identifies four different approaches to completing Master Plans corresponding to different levels of assessment. Regardless of the approach selected, all Master Plans must follow at least the first two phases of the Class Environmental Assessment process.

- **Approach 1**, the most common approach, is to follow Phases 1 and 2 as defined above, then use the Master Plan as a basis for future investigations of site specific Schedule 'B' and 'C' projects. Any Schedule 'B' and 'C' projects that need specific Phase 2 work and Phases 3 and 4 work, usually have this Phase 2, 3 and 4 deferred until the actual project is implemented.
- **Approach 2**, is to complete all of the work necessary for Schedule 'B' site specific projects at the time they are identified. Using this approach, a municipality would identify everything it needed in the first five years and would complete all the site specific work required, including public consultation to meet Class EA requirements. The Master Plan in such cases has to be completed with enough detail so that the public in site specific locations can be reasonably informed, and so that the approving government Agencies (Conservation Authorities, Natural Resources, Federal Department of Fisheries and Oceans, Transportation Canada etc.) can be satisfied that their concerns will be addressed before construction commences.
- **Approach 3**, is to complete the requirements of Schedule 'B' and Schedule 'C' at the Master Plan stage.
- **Approach 4**, is to integrate approvals under the EA and Planning Acts. For example, the preparation of new or amended Official Plans could be undertaken simultaneously with Master Plans for water, wastewater and transportation, and approval for both sought through the same process.

For the purpose of this study, the City of Mississauga has selected Schedule B and Approach 1 for undertaking the Master Plan. The Master Plan will therefore be completed such that the level of investigation, consultation and documentation is sufficient to fulfill the Municipal Class EA requirements for the Schedule B and C projects identified in the Master Plan.

Accordingly, this report provides a study which comprises the two phases of the Class EA process, namely:

- **Phase 1**: Establish the Problem or Opportunity
- **Phase 2**: Identify and Assess Alternative Solutions to the Problem, and Select a Preferred Alternative

Following the understanding of problem/opportunity component, alternative solutions will be assessed and a recommended plan (i.e. Preferred Alternative) to provide alternative solutions and a strategy for implementing a number of projects across the Cooksville Creek watershed will be proposed.

1.3 Background

The Cooksville Creek has a drainage area of 33.9 Km^2, with 94% of the total area developed. The land use distribution in the watershed is approximately 60% residential, 34% industrial/commercial and 6% open space. The climate of the Cooksville Watershed can be characterized as moderately cool with an average annual temperature of about 7.5°C and an average annual precipitation of about 793mm. The total water equivalent of mean annual snow represents approximately 115mm. The watershed is under significant pressure from urban development. **Figure 1.2** shows land use changes in an urban area within the watershed (i.e. Hurontario St. and QEW) since the forties of the twentieth century. As opposed to a predominant agricultural land use with woodlots and natural creek corridor in the forties, residential land use dominates the landscape at present time.

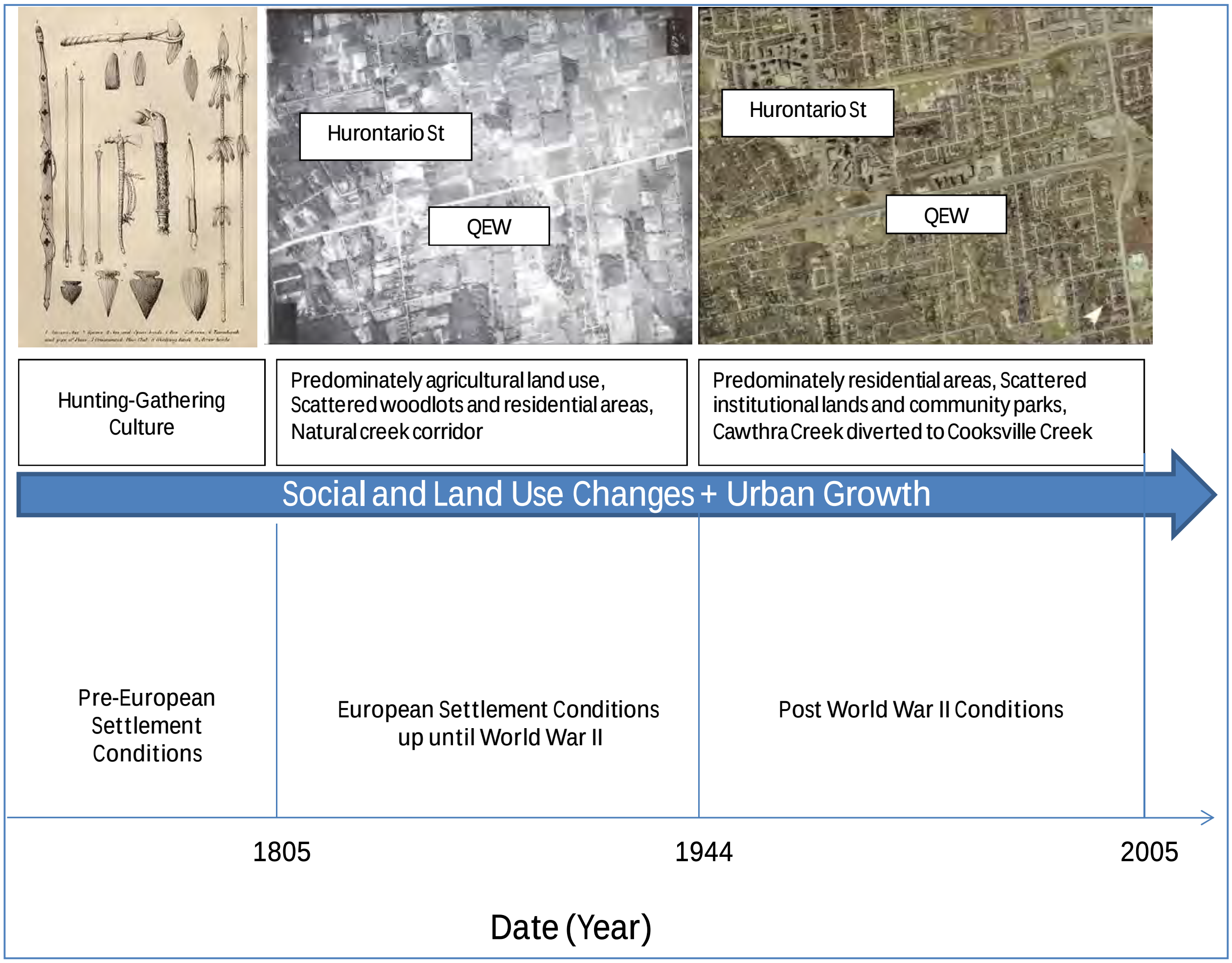


Figure 1.2 Age of Development Map for the Cooksville Creek Watershed (Hurontario St. and QEW Intersection as an example)

According to previous studies (EWRG, 2002), formal floodplain management within Cooksville Creek dates back to 1969. Flat floodplains in addition to highly erodible shale substrate along Cooksville Creek have resulted in increasing the susceptibility of areas along the Creek to flooding-related issues such as flooding, erosion, and water quality issues.

The urbanization of the Cooksville Creek watershed (about 94% of the watershed area is under residential and industrial/commercial land use) has altered the natural hydrological cycle within the watershed and negatively affected the hydrology of Cooksville Creek. Although highly modified, the Cooksville Creek corridor is an important feature of the watershed. The Cooksville Creek watershed is dominated by urban land uses and has very little natural area remaining (9.6%). The percentages of forest (2.2%) and wetland habitat (0.2%) fall short of Environment Canada Habitat Guidelines which stress that a minimum of 30% forest coverage within a watershed is required in order to maintain forest interior species and area sensitive species, and that each watershed have greater than 10% of it’s land in wetland habitat (or 6% of any subwatershed). Protection of the remaining natural sites is crucial to maintaining the ecological integrity and species diversity within the localized area and providing surrounding residents access to a significant green space.

Environmental changes that have occurred to the Cooksville Creek Watershed over years of increasing urban development include:

- The hydrology of the Cooksville Creek watershed is typical of an urban watershed. More specifically, the runoff coefficient is high, the hydrograph is flashy, and surface runoff volume is high due to high percentage of impervious areas;
- Water quality degradation resulting from urban-driven point and non-point source pollution such as increasing chloride levels;
- Stream erosion issues resulting from the alteration of the hydrology of the watershed due to urban development; and
- Natural heritage degradation including negative impacts to fish habitat (e.g. fish barriers and riparian cover) and the decrease of the percentage of terrestrial areas within the watershed.

1.4 Flood Management approach

1.4.1 General

Floods endanger lives, cause heavy economic losses and can have severe environmental consequences by eroding streams and transporting contaminants on their way. Although a natural phenomena, humans can reduce the likelihood of flooding and limit their impacts through sound and adequate measures that accommodate environmental and socio-economic concerns.

In general, the alteration of the natural hydrological cycle as a result of urbanization (i.e. increasing impervious cover) is manifested by significant changes in the proportion of precipitation that infiltrates into the ground, evaporates back into the atmosphere and enters drainage features as surface runoff. In particular, for a given storm event, the total volume of stormwater runoff reaching a stream increases 3 to 5 fold compared to rural or forested watersheds, accompanied with an increase in magnitude and duration of peak runoff (**Figure 1.3**). Implications of these impacts include flooding issues, property and infrastructure damage, and modifications in stream morphology due to excessive erosion and/or sedimentation.

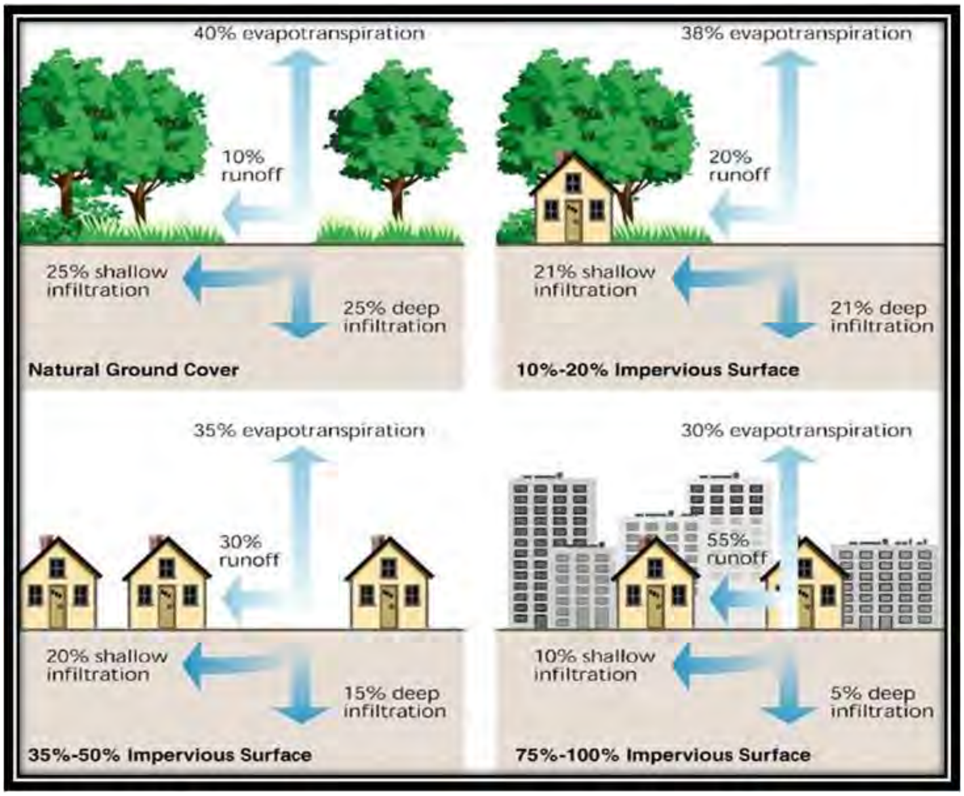


Figure 1.3 Impact of Urbanization on the Natural Hydrological Cycle

1.4.2 Traditional and Non-Traditional Flood Control Measures

This study adopts a progressive vision of looking at flood control for environmental and socio-economic purposes. The vision combines traditional measures that have been historically proposed to manage flood issues within the Cooksville Creek watershed (EWRG, 2002) with innovative approaches that not only address flooding issues but also consider the management of other environmental features and functions in the watershed such as water quality and erosion. Therefore, the study analyzes suites of flood management measures and proposes an implementation strategy to assure that the solutions proposed are tangible and implementable.

Traditional flood control measures include measures such as increasing road crossing capacity, floodproofing and/or enlarging watercourses. Non-traditional measures include measures such as flood storage above and underground in addition to Low Impact Development (i.e. source and conveyance control). Combining both measures at the watershed scale (e.g. flood storage witin a portion of the watershed) and at the site scale such as increasing road crossing capacity to convey more water would lead to major socio-economic and environmental benefits.

2.0 IDENTIFICATION OF PROBLEMS AND OPPORTUNITIES

This chapter describes the key environmental issues at the Cooksville Creek watershed scale, and presents their relevance to the study objectives. The assessment of the environmental problems below is founded on the premise that hydrology is a key driver of environmental features and functions at the watershed scale. Therefore, examining flood management entails the study of impacts on other resources within Cooksville Creek Watershed, mainly water quality, fisheries and stream erosion. The chapter also presents general opportunities that are introduced to set-up a framework which could identify and propose specific solutions and implementation strategies for flood management within Cooksville Creek Watershed as per the primary and secondary objectives of the study (Section 1.1).

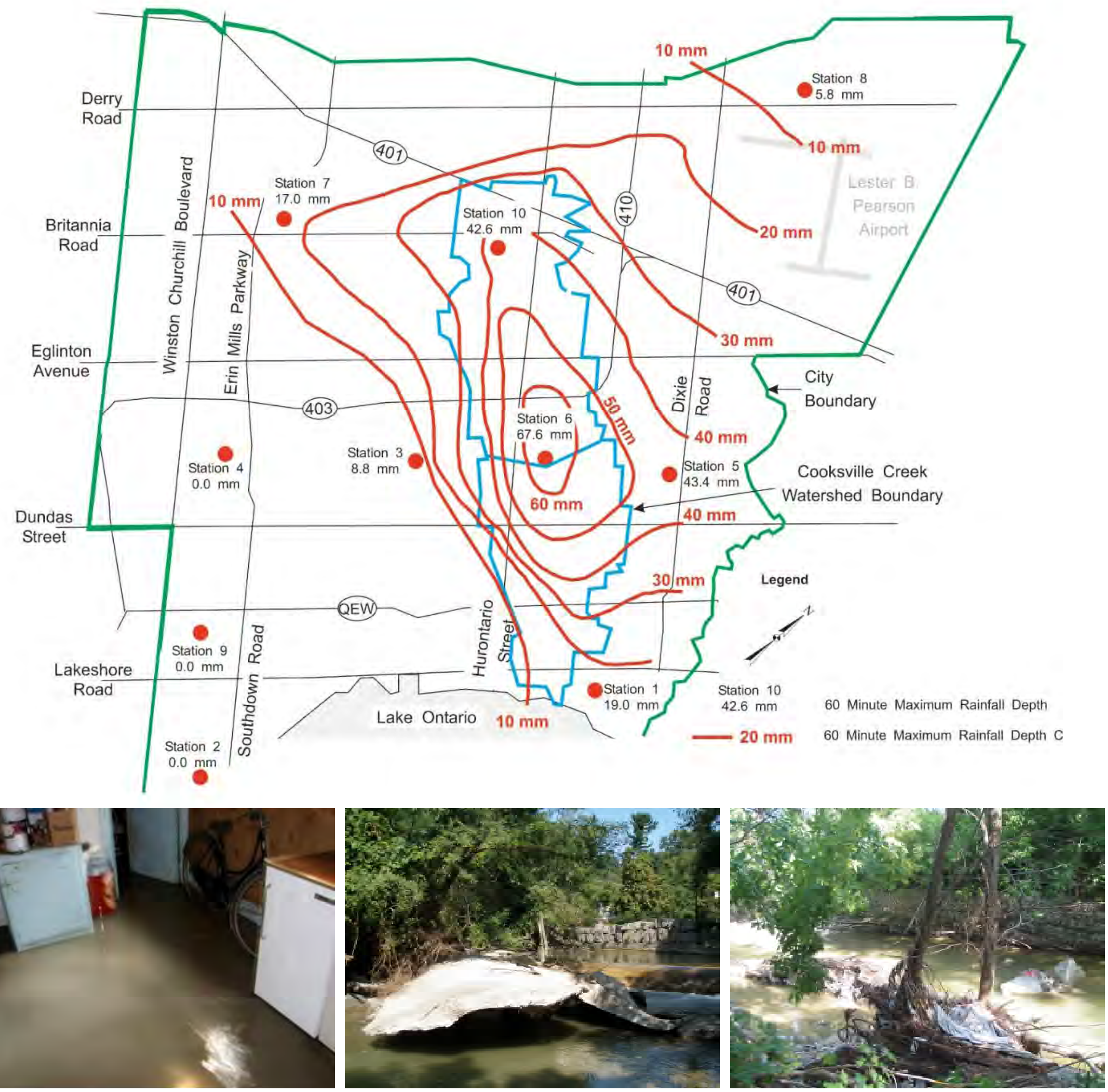
2.1 Problems

2.1.1 Flooding

The Cooksville Creek watershed exhibits a flashy hydrologic response typical of highly urbanized watersheds developed without the benefits of updated stormwater management infrastructure. Flooding and drainage issues exist within the watershed in areas where development has reduced channel conveyance and restricted floodplain capacity, and as a result caused backwaters to flood upstream reaches. Approximately 304 buildings can be inundated in the middle and lower part of the watershed for the regulatory flood (i.e. Hurricane Hazel) and 119 buildings for the 100-year storm (EWRG, 2002).

On August 4, 2009, significant flood damages occurred within Cooksville Creek watershed (**Figure 2.1**). The damages took place in different areas and covered many land uses including:

- Buildings (i.e. basements and yards);
- Municipal infrastructure;
- Fences and pedestrian bridges, and
- Trails and channel protection measures



Basement flooding   Degraded municipal infrastructure   Stream erosion

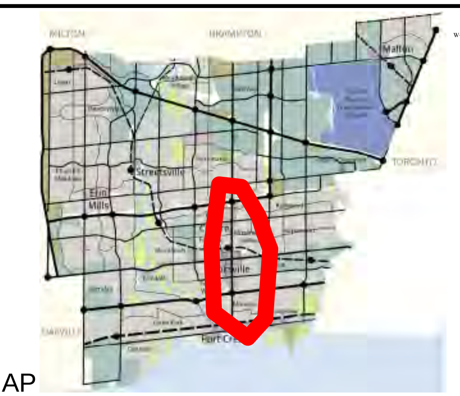
Figure 2.1 Above: An isohyetal map representing rainfall depth across the Cooksville Creek Watershed during the August 4, 2009 Storm Event (EWRG, 2010). Below: Impacts of the August 4, 2009 Storm Event within the Cooksville Creek Watershed

Approximately 68 mm of rainfall was recorded in one hour on August 4, 2009. **Figure 2.1** shows the rainfall depth distribution across the Cooksville Creek watershed, where it can be noticed that the highest rainfall depth was recorded at the centre of the watershed. This localized high intensity rainfall event generated the highest streamflow rate ever recorded by the Water Survey of Canada (WSC) Cooksville Creek near Cooksville gauge (02HB030, located roughly at the centre of the watershed). The runoff volume generated was approximately 571,500 m^3 from an upstream drainage area of 20.6 Km^2. Runoff estimates from the August 4, 2009 event showed a runoff coefficient of 0.61 which reveals the high runoff proportion of the watershed's water budget (**Figure 1.3**), which is typical of urban watersheds.

Generally speaking, most of the inundation occurs in the middle and lower areas of the watershed (**Figure 2.2**). Inundation affects approximately 304 buildings for the Regulatory Flood and approximately 119 for the 100 year flood (EWRG, 2002). In terms of location within the watershed, these buildings are classified as follows:

- From CNR to the QEW, approximately 108 buildings could potentially be flooded for the regulatory storm. The majority of the buildings could be flooded because of the CNR crossing low capacity (130 m^3/s compared to Regional Flow of 295 m^3/s).
- From QEW to King Street East, 108 buildings could potentially be flooded due to QEW crossing low capacity (110 m^3/s compared to Regional Flow of 295 m^3/s).
- From the CPR to Central Parkway East, where CPR crossing has a capacity of 125 m^3/s compared to 250 m^3/s for the Regional Flow.

KEY MAP



LEGEND:

- Streams
- Subwatershed Boundary

Properties Susceptible to Flooding During Regulatory Storm

Location

- Burnhamthorpe Road East to Eglinton Avenue East
- CNR to QEW
- CPR To Mississauga Valley Boulevard (North)
- Eglinton Avenue West to Matheson Boulevard West
- Highway 403 to Eglinton Avenue East
- King Street East to CPR
- Lake Ontario to CNR
- QEW to King Street East

NOTES:

Base Mapping was provided by City of Mississauga

0 0.5 1 2 Kilometers

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Mississauga, ON L4W 5B2
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COOKSVILLE CREEK FLOOD EVALUATION MASTER PLAN EA

No. of Properties Susceptible to Flooding During Regulatory Storm

FIGURE No. 2.2

DATE: May 2012

2.1.2 Erosion

CVC (2010) indicates that most of the Cooksville creek reaches are either in adjustment or in a transitional/stressed state. Accordingly, Cooksville Creek is a watercourse that is actively adjusting in the form of widening and degradation (incision). These two processes have combined to create an over-sized cross-section which was necessitated by the need to accommodate urbanized peak flow events but, for much of the year, supports minimal baseflows.

Existing and historic land use practices and channel modifications within the Cooksville Creek watershed have combined to create a watercourse that is not stable in the long term. Fluvial geomorphic issues observed along Cooksville Creek are manifested in the following:

- Downward erosion of the channel into the underlying shale bedrock;
- Channelization of Cooksville Creek has resulted in a loss of the historical meander pattern and associated pools and riffles ;
- Extensive failure of bank and bed protection.

Cooksville Creek has experienced significant erosion over the last 20 years. During this period, the City of Mississauga has undertaken restoration works at 12 sites, where $8 million was spent to restore Cooksville Creek. In addition, the City of Mississauga has identified 10 priority stream erosion control projects for the period between 2011 and 2020 (**Figure 2.3**).

2.1.3 Water quality

Surface water within Cooksville Creek has high levels of E coli and Chloride. Water temperatures do not comply with the Provincial standards for cold water habitat. Under dry weather conditions, concentrations for nutrients and metals meet guidelines. However, wet weather concentrations/loadings are significantly high for nutrients and metals and exceed guidelines.

In regard to groundwater quality, groundwater is very hard along the Cooksville creek. The groundwater throughout the watershed has high concentration of sodium and chloride due to the intensive application of road salt. The concentration of sulfate is relatively high. In general, the groundwater in the watershed is not suitable for drinking purpose, but it can be used for irrigation and other commercial purposes. All parameters of concern are within permissible limits except for Un-Ionized Ammonia and Dissolved Oxygen, where some samples showed higher and lower concentrations, respectively.

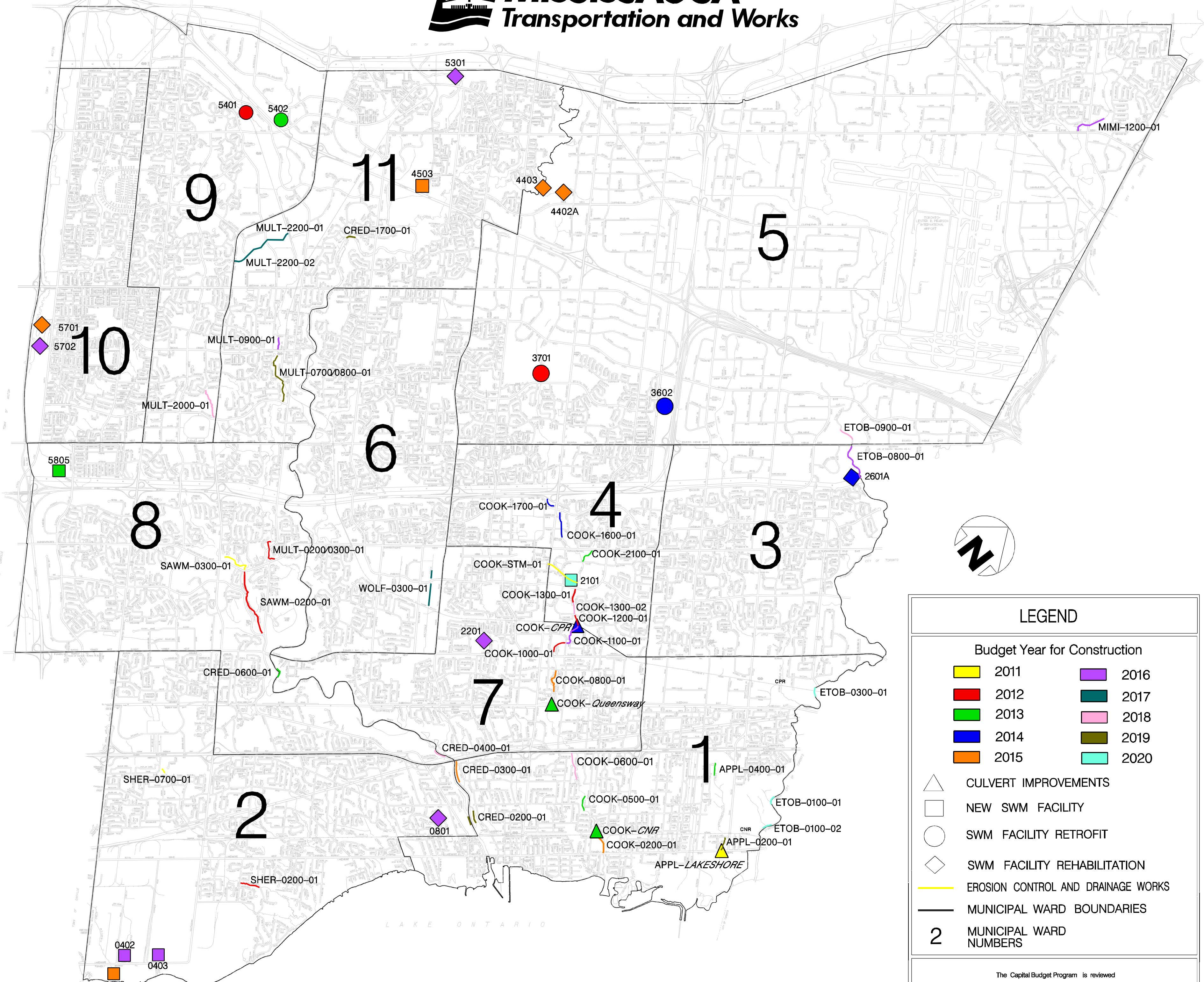
In general, most of the watershed is not inhabited by fish. Instream barriers are a primary factor that exclude fish upstream of Atwater Boulevard (lower watershed). Other fish habitat issues include water temperatures exceeding 26°C and substrate for spawning needs.

MISSISSAUGA
Transportation and Works

WATERCOURSE AND STORM DRAINAGE IMPROVEMENTS 2011–2020

TRANSPORTATION AND WORKS

FINAL



METRIC 2500M 2000 1500 1000 500 0 2.5 5 KM

IMPERIAL 1 0 1 2 3 MILES

SCALE 1:30,000

LEGEND

Budget Year for Construction

- 2011
- 2012
- 2013
- 2014
- 2015
- 2016
- 2017
- 2018
- 2019
- 2020

- CULVERT IMPROVEMENTS
- NEW SWM FACILITY
- SWM FACILITY RETROFIT
- SWM FACILITY REHABILITATION
- EROSION CONTROL AND DRAINAGE WORKS
- MUNICIPAL WARD BOUNDARIES
- 2 MUNICIPAL WARD NUMBERS

The Capital Budget Program is reviewed on an annual basis and is subject to change.

For information please call Transportation and Infrastructure Planning at 615–3200 ext. 3133

WATERCOURSE EROSION CONTROL PROJECT INDEX

	2011	
SHER–0700–01	SHERIDAN CREEK EROSION CONTROL (DES 2010)	D/S OF BENEDET DRIVE
	2012	
COOK–1000–01	COOKSVILLE CREEK EROSION CONTROL (DES 2010)	N OF DUNDAS ST E BEHIND JAGUAR VALLEY DR
MULT–0200/0300–01	MULLET CREEK EROSION CONTROL (DES 2008)	BURNHAMTHORPE RD W TO BEHIND WOODCHUCK LANE (MCRS #2)
SAWM–0200–01	SAWMILL CREEK EROSION CONTROL (DES 2011)	BURNHAMTHORPE RD TO THE COLLEGEWAY
SAWM–0300–01	SAWMILL CREEK EROSION CONTROL (DES 2011)	ERIN MILLS PKWY TO BURNHAMTHORPE RD W
SHER–0200–01	SHERIDAN CREEK EROSION CONTROL (DES 2001)	CLARKSON RD TO MEADOW WOOD RD
	2013	
COOK–0500–01	COOKSVILLE CREEK EROSION CONTROL (DES 2010)	WILLA RD TO ORANO AVE
COOK–2100–01	COOKSVILLE CREEK EROSION CONTROL (DES 2011)	BURNHAMTHORPE RD E TO MISSISSAUGA VALLEY BLVD, EAST BRANCH
CRED–0600–01	CREDIT RIVER EROSION CONTROL (DES 2010)	S OF DUNDAS ST W BEHIND JARVIS ST (CRAMS #21)
APPL–0400–01	APPLEWOOD CREEK EROSION CONTROL (DES 2011)	BEHIND DIXIE OUTLET MALL
	2014	
COOK–1600–01	COOKSVILLE CREEK EROSION CONTROL (DES 2011)	RATHBURN RD TO ABSOLUTE AVE
COOK–1700–01	COOKSVILLE CREEK EROSION CONTROL (DES 2013)	HWY 403 TO HURONTARIO ST
	2015	
COOK–0800–01	COOKSVILLE CREEK EROSION CONTROL (DES 2013)	KING ST TO NORTH OF PAISLEY BLVD
COOK–0200–01	COOKSVILLE CREEK EROSION CONTROL (DES 2014)	CAWTHRA CREEK DIVERSION, N OF LAKESHORE RD E
CRED–0300–01	CREDIT RIVER EROSION CONTROL (DES 2013)	S OF QEW, BEHIND PINETREE CRES (CRAMS #28)
	2016	
COOK–1100–01	COOKSVILLE CREEK EROSION CONTROL (DES 2014)	CPR TO KIRWIN AVE.
ETOB–0800–01	ETOBICOKE CREEK EROSION CONTROL (DES 2014)	EGLINTON AVE TO HYDRO CORRIDOR
MIMI–1200–01	MIMICO CREEK EROSION CONTROL (DES 2014)	S OF ETUDE DR TO DERRY
MULT–0900–01	MULLET CREEK EROSION CONTROL (DES 2014)	TANNERY ST TO THOMAS ST
	2017	
MULT–2200–01	MULLET CREEK EROSION CONTROL (DES 2014)	WABUKAYNE TRIB, U/S OF CPR
MULT–2200–02	MULLET CREEK EROSION CONTROL (DES 2014)	WABUKAYNE TRIB, D/S OF ERIN MILLS PKWY
WOLF–0300–01	WOLFEDALE CREEK EROSION CONTROL (DES 2015)	N AND S OF CENTRAL PARKWAY
	2018	
COOK–0600–01	COOKSVILLE CREEK EROSION CONTROL (DES 2015)	QEW TO ELAINE TRAIL
COOK–1300–02	COOKSVILLE CREEK EROSION CONTROL (DES 2017)	RHONDA VALLEY BLVD TO MISSISSAUGA VALLEY BLVD
CRED–0400–01	CREDIT RIVER EROSION CONTROL (DES 2016)	N OF QEW BEHIND MISSISSAUGA CRES (CRAMS #27)
ETOB–0900–01	ETOBICOKE CREEK EROSION CONTROL (DES 2018)	N OF EGLINTON AVE
MULT–2000–01	MULLET CREEK EROSION CONTROL (DES 2016)	QUEN. TRIB. U/S OF ERIN MILLS PKWY TO MIDDLEBURY DR
	2019	
APPL–0200–01	APPLEWOOD CREEK EROSION CONTROL (DES 2019)	CNR TO S. OF LAKESHORE
CRED–0200–01	CREDIT RIVER EROSION CONTROL (DES 2016)	N. OF CNR, BEHIND MISSISSAUAGA RD & STAVEBANK RD (CRAMS #29/30)
CRED–1700–01	CREDIT RIVER EROSION CONTROL WORKS (DES 2016)	W OF CREDITVIEW RD BEHIND KENNINGHALL BLVD (CRAMS #4)
MULT–0700/0800–01	MULLET CREEK EROSION CONTROL (DES 2019)	GO TRANSIT TO D/S OF ERIN CENTRE BLVD
	2020	
ETOB–0300–01	ETOBICOKE CREEK EROSION CONTROL (DES 2020)	U/S & D/S OF CPR, S. OF DUNDAS ST
ETOB–0100–01	ETOBICOKE CREEK EROSION CONTROL (DES 2020)	D/S OF QEW (ADJACENT TO TORONTO GOLF CLUB)
ETOB–0100–02	ETOBICOKE CREEK EROSION CONTROL (DES 2020)	U/S OF CNR (ADJACENT TO TORONTO GOLF CLUB)

CONVEYANCE AND STORM DRAINAGE IMPROVEMENTS PROJECT INDEX

	2011	
APPL–0100–01	APPLEWOOD CREEK CHANNEL IMPROVEMENTS (DES 2011)	D/S OF LAKESHORE RD E
COOK–STM–01	MISSISSAUGA VALLEY COMMUNITY CTR (DES 2011)	LID PILOT PROJECT
COOK–STM–02	SQUARE ONE STM SEWER REPAIR (DES 2011)	HURONTRAIO ST TO COOKSVILLE CK
APPL–*Lakeshore*	APPLEWOOD CREEK CROSSING IMPROVEMENT (DES 2011)	CULVERT UNDER LAKESHORE RD E
	2012	
COOK–1200–01	COOKSVILLE CREEK CHANNELIZATION (DES 2011)	MISSISSAUGA VALLEY BLVD TO CPR
COOK–1300–01	COOKSVILLE CREEK DYKING (DES 2011)	D/S OF CENTRAL PKWY E
	2013	
COOK–*CNR*	COOKSVILLE CREEK CULVERT IMPROVEMENTS (DES 2011)	CNR CULVERT
COOK–*Queensway*	COOKSVILLE CREEK CULVERT IMPROVEMENTS (DES 2011)	QUEENSWAY EAST CULVERT
	2014	
COOK–*CPR*	COOKSVILLE CREEK CULVERT IMPROVEMENT (DES 2011)	CPR CULVERT
	2015	
COOK–STM–01	COOKSVILLE CREEK – SQUARE ONE STORM SEWER REPAIR (DES 2011)	HURONTARIO ST TO COOKSVILLE CREEK

STORMWATER MANAGEMENT FACILITY PROJECT INDEX

	2012	
#5401	RETROFIT MULLET CREEK ARCH SWM POND (DES 2011)	W OF ARGENTIA RD & N OF DERRY RD W
#3701	RETROFIT COOKSVILLE CREEK SWM POND (DES 2012)	BRISTOL RD BETWEEN MCLAUGHLIN & HURONTARIO
	2013	
#5805	NEW FACILITY SAWMILL CREEK (GLEN ERIN BROOK) SWM POND (DES 2013)	N OF HWY 403, W OF WINSTON CHURCHILL
#5402	RETROFIT MULLET CREEK SWM POND (DES 2012)	N OF DERRY RD & W OF SENTEX DR
	2014	
#2601A	REHABILITATION EASTGATE BUSINESS PARK (2014)	N OF HYDRO CORRIDOR, W OF ETOBICOKE CREEK
#3602	RETROFIT LITTLE ETOBICOKE CREEK TIMBERLEA SWM POND (DES 2014)	S OF MATHESON BLVD, E OF DRIFTCURRENT DR
	2015	
#5701	REHABILITATION CHURCHHILL MEADOWS (DES 2015)	W OF NINTH LINE, N OF THOMAS ST
#4403	REHABILITATION FLETCHERS CREEK FFP3 (DES 2015)	E OF MCLAUGHLIN RD, S OF GOLDEN HILLS WAY
#4402A	REHABILITATION SHIPP–HIGGINS (DES 2015)	E OF MCLAUGHLIN RD, AT FLETCHERS CREEK
#0401	CLEARVIEW CREEK SWM (QUALITY & QUANTITY) FACILITY (DES 2015)	S OF LAKESHORE RD W
#4503	MEADOWVALE AREA SWM (QUALITY & QUANTITY) FACILITY (DES 2014)	N OF HWY 401, E OF CREDIT RIVER
	2016	
#5702	REHABILITATION CHURCHHILL MEADOWS (DES 2016)	W OF NINTH LINE, AT THOMAS ST
#0801	REHABILITATION MATTAMY LORNE PARK (DES 2016)	W OF MISSISSAUGA RD, N OF CPR
#2201	REHABILITATION MARY FIX CREEK (DES 2016)	S OF HILLCREST AVE, W OF PARKERHILL
#5301	REHABILITATION FIELD RUN SUBDIVISION (DES 2016)	S OF HWY 407, W OF SECOND LINE W
#0403	LAKESIDE CREEK SWM (QUALITY & QUANTITY) FACILITY (DES 2016)	LAKESHORE RD WEST AT CLARKSON WWTP
#0402	AVONHEAD CREEK SWM (QUALITY & QUANTITY) FACILITY (DES 2016)	N OF LAKESHORE RD, W OF HAZELHURST RD
	2020	
#2101	NEW FACILITY COOKSVILLE CREEK SWM POND (DES 2020)	CITY CTR AT MISSISSAUGA VLLY BLVD & CENTRAL PKWY. E

...\2011 Capital Works Forecast Ma 2011/03/10 2:08:18 PM

2.2 Opportunities

Previous flood records in the watershed in addition to the August 4, 2009 event emphasize the need to mitigate floods in the study area. Traditional mitigation measures such as the enlargement of road/railway crossings, channel enlargement, flood proofing and non-traditional stormwater management alternatives such as LID measures and treatment train approach should be implemented to reduce potential flood damages and provide water quality and stream restoration benefits.

The implementation of innovative flood management measures consistent with the objectives of this study will reduce flooding and erosion problems, improve water quality conditions, and improve aquatic habitat conditions. The proposed measures are consistent with the recommendations of previous studies and reports that set a foundation for water and environmental management at various scales, including:

- At the watershed scale (Credit River Water Management Strategy Update (CRWMSU, 2007) and Cooksville Creek watershed study (CVC, 2010))

The recommended approach in the CRWMSU is two-pronged, and involves:

1. A broad suite of stormwater management measures for future development must be applied and be more comprehensive if further degradation of the watershed is not to occur;

2. In existing urban areas (and rural areas), greater emphasis must be placed on incorporating sustainable stormwater management practices in order to improve environmental conditions and therefore meet various environmental

- Municipal-wide scale (the City of Mississauga Stormwater Quality Control Strategy Update Study)

The main objective of **the City of Mississauga Water Quality Strategy** is to develop a city-wide strategy to implement the storm water quality controls required to service developing sites. The strategy was developed to provide more efficient protection of the City's watercourse systems in accordance with all applicable regulations and guidelines and at reduced construction costs (to developers) and maintenance costs (for the City).

Flood management alternatives should be addressed within the Cooksville Creek watershed. These alternatives can have many objectives (e.g. CRWMSU objectives) such as flooding control (as a primary objective), water quality, water balance, stream processes, and terrestrial and aquatic habitat. The application of these alternatives can provide restoration opportunities across the watershed. The City of Mississauga Water Quality Strategy (Aquafor, 2011) addresses stormwater quality management using a comprehensive approach which incorporates providing a myriad of environmental benefits including water balance improvement. More specifically, the City of Mississauga Water Quality Strategy has emphasized that managing surface runoff volume has great potential of decreasing pollutant load by minimizing surface runoff (which is the key transporting agent of surface contaminants) and optimizing infiltration and evapotranspiration.

3.0 REVIEW OF BACKGROUND DOCUMENTS

Several documents have described the environmental conditions within the Cooksville Creek watershed and discussed the flooding issues within the context of identifying natural and urban features, defining floodlines and flooding issues, and proposing flood mitigation measures. These documents include the following:

Cooksville Creek Flood Remediation Plan (EWRG, 2002)

The Cooksville Creek Flood Remediation Plan complemented mitigation and remedial measures proposed in previous flood studies that covered the Cooksville Creek watershed such as the Cooksville Creek Watershed Study (Dillon, 1979) and Cooksville Creek Floodline Mapping Study (RVA, 1996). The study defines flood flows, spill zones, frequency and number of buildings which flood within the Cooksville Creek Watershed. The main objective of the Cooksville Creek Flood Remediation Plan was to propose measures to mitigate potential and actual flood damages within the Cooksville watershed for the Regulatory storm. The report proposes traditional measures such as crossing enlargement and flood proofing based on a comprehensive analysis of the capacity (or lack thereof) of existing crossings as well as channel capacity. The report provides insight with respect to the types of measures that were considered together with the evaluation approach.

The remedial measures considered by EWRG (2002) to mitigate flood damage during the Regulatory storm included the following:

- Measures that modify the extent of flooding
  - Structural measures including crossing enlargement, watercourse enlargement, dykes/berms, and reservoirs;
- Corrective measures that modify the susceptibility to flooding
  - Structural measures including flood proofing and relocation
  - Non-structural measures including evacuation, flood fighting and flood forecasting
- Preventive measures that modify the susceptibility to flooding
  - Regulations (floodplains)
  - Zoning by law
  - Special policy areas
- Modify the regulatory flood standard

The recommendations of the study include the following:

- The City continue to implement the current CVC one zone approach
- The City should undertake measures on their property or easements to raise the level of protection where feasible

- The City encourages external agencies to ensure that their crossings can convey the regulatory flood without building flooding
- The City advise property owners of the risk to life and property damage that could result from being in the Regulatory Floodplain
- The City ensure that any re-development within the Cooksville Creek watershed be accompanied by the appropriate stormwater management and flood protection measures

Special Policy Area Study for the Cooksville Creek Floodplain (Phillips, 2003)

The Special Policy Area Study for the Cooksville Creek Floodplain considers the Cooksville Creek Watershed but focuses on properties that were considered as Special Policy Areas (SPAs). The primary objective of the study was to evaluate technical and policy alternatives in order to consider development and redevelopment potential. A couple of potential sites for storage on table lands (Bristol Road and Mississauga Valley Boulevard) were noted. A tunneling option was also considered.

Cooksville Creek Watershed Study (CVC, 2010)

Cooksville Creek Watershed study involves three phases; Watershed Characterization, Evaluation of Alternatives and Implementation. To date, the first phase has been completed and the Evaluation of Alternatives has been initiated. The watershed study addresses a broad range of objectives and issues including flooding, erosion, water quality together with the protection and enhancement of aquatic and terrestrial resources. Of relevance to this study is the fact that several candidate sites located on table land, or upstream of flood susceptible areas within the creek have been identified. If implemented, these measures would reduce flooding.

City of Mississauga Water Quality Control Strategy Update Study (Aquafor, 2011)

The City of Mississauga Water Quality Control Strategy Update Study has noted that only 15 percent of the city has stormwater management facilities in place. The study has identified subsequent sites and proposed a program involving source and conveyance control measures which address a variety of objectives. Collectively, these measures would assist in reducing flooding for the more frequent events.

City of Mississauga Development Charges Study (Aquafor, 2009)

Development charges is a portion of charges paid by developers, and generally used to pay the cost of new capital projects required as a result of growth. **Table 3.1** shows the breakdown of identified storm drainage works and total cost for each category. These works are anticipated to take place within future development and re-development growth lands that has an area of 919 hectares, which represents approximately 3.2% of the total lands within the City of Mississauga.

According to the study, the resulting development charge for storm drainage is $77,000 per net hectare.

Table 3.1 Storm Drainage Categories and Total Cost

Storm Drainage Component	Total Cost ($)
Stream erosion control works	110,777,500
Conveyance improvements	21,001,000
Stormwater management	90,310,600
Storm sewer over sizing	4,701,000
Background studies and monitoring	4,560,000

4.0 EXISTING CONDITIONS

4.1 Study Area

The Cooksville Creek watershed is located within the City of Mississauga, east of the Credit River, that drains an area of approximately 33.9 Km^2 (3,390 ha) outletting to Lake Ontario. Understanding environmental and urban features and functions within the Cooksville Creek watershed is a necessary precursor for addressing flood management scenarios and implementation strategies. In the following sections, a characterization-based effort is undertaken to define the study area by describing the natural environment, existing municipal infrastructure, and socio-economic environment within the watershed.

4.2 Natural Environment

4.2.1 Geology , Physiography and Soils

Cooksville Creek watershed overburden is characterized by six stratigraphic units: Maple Formation, Halton Till, Iroquois Lake deposits, glaciolacustrine deposits, organic deposits and modern alluvium. The Cooksville Creek watershed study shows that the overburden is less than 10 m for most areas southwest of Eglinton Ave. However, northwest of Eglinton Ave. the overburden reaches as thick as 75m

The Cooksville Creek watershed is located in the southwest end of the South Slope enclosed by the Oak Ridges Moraine to the north, the Niagara Escarpment to the west, and the shoreline of Lake Ontario to the southeast. The southwest end of the South Slope comprises four sub-physiographical units: Iroquois Plain, Fluted Till Plain, Trafalgar Moraine and Peel Plain (Chapman 1984). Cooksville Creek watershed straddles the Iroquois Plain and the Fluted Till Plain.

The upper watershed corresponds to till plain underlain by continuous Halton Till. Middle watershed consists mainly of the till plain and shale plain. Lower watershed corresponds to the Iroquois Sand Plain with a few patches of outcropped bedrock and Halton Till.

4.2.2 Terrestrial Communities

The Mississauga Natural Areas Survey (NAS) includes a comprehensive survey of plants and animals in the Cooksville Creek watershed. Compared to other areas in the Credit River watershed, natural areas within Cooksville Creek watershed have had relatively good botanical coverage since the NAS began surveying in 1996. Records of flora and fauna are shown in **Table 4.1.**

Table 4.1 Flora and Fauna within the Cooksville Creek watershed (CVC, 2010)

Flora			Fauna		
Total	Native (Non-native)	Of Conservation Concern	Total	Native (Non-native)	Of Conservation Concern
594	408 (186)	175	118	111 (7)	80

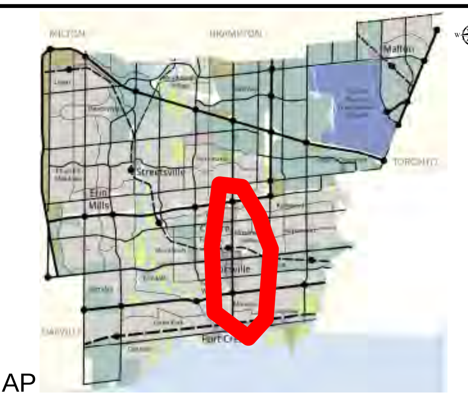
Table 4.2 shows the ecological communities of the Cooksville Creek watershed, mapped primarily using the Ecological Land Classification (ELC) System for Southern Ontario. As shown in **Table 4.2**, Ecological communities were separated into distinct types: Forest, Wetland, Successional, Aquatic, and Urban.

Table 4.2 Ecological communities within the Cooksville Creek Watershed (CVC, 2010)

Ecological community	Coverage in hectares (% of watershed)
Natural Forest	79.1 (2.2)
Wetland	6.8 (0.2)
Successional	244.1 (7.2)
Aquatic	0.5 (0.02)

Natural land uses cover only 9.6% of the Cooksville Creek watershed (natural areas include woodlands and wetlands as compared to open space which includes parks and other vacant uses). Where natural habitat occurs today it is highly fragmented and only a small remnant of pre-settlement conditions. Urbanisation, intensification and increased human use continue to put pressure on these remaining natural habitats. Forest habitat exists is often small in size, fragmented and isolated from one another. Interior forest conditions do not appear to be frequent in the study area, and forest fragments across the watershed appear to be impacted by trails, human disturbance, and encroachment. Present mapping indicates that wetland ecosystems amount to less than 1% of the study area. Wetlands provide important ecological goods and services on many levels and support the health of the entire watershed.

Opportunities to enhance and improve the ecological features of this highly urbanised watershed should focus not only on existing natural habitats but also on the entire urban forest and the possibilities presented for ecological restoration in manicured open spaces.



KEY MAP

LEGEND:

- Subwatershed Boundary
- Streams
- Special Management Areas
- Natural Areas

NOTES:

Base Mapping was provided by City of Mississauga

0 0.5 1 2 Kilometers

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COOKSVILLE CREEK FLOOD EVALUATION MASTER PLAN EA

Natural Areas within the Cooksville Creek Watershed

FIGURE No. 4.1

DATE: July 2012

4.2.3 Fisheries

In general, most of the watershed is not inhabited by fish. No reaches upstream of the QEW contained fish. Sampling at the mouth had the most species, including a mix of lake and river species. The presence of fish barriers seems to be the most limiting factor affecting fish distribution, however, fairly natural sections in some areas reporting crayfish may indicate good potential for restoring fish populations throughout most of Cooksville Creek.

Key fisheries issues include:

- Unstable flows (high storm flows and low baseflow) impact habitat, ultimately limiting fish survival.
- Poor water quality due to unmanaged stormwater, salt, water temperatures and nutrients.

4.2.4 Hydrology

The Impact Monitoring Program within the Cooksville Creek watershed has used a group of rain gauges and streamflow stations (CVC, 2010) which revealed that the alteration in the hydrology of the watershed is primarily manifested by a rapid response to rain events that is typical of an urbanized watershed.

Hydrological parameters that are relevant to flooding issues in the watershed and represent the increasing impact of urban development include:

- Time from the peak rain to the peak flow can be as little as 15 minutes.
- The difference between low flows and maximum flows is extremely high and can reach several orders of magnitude greater than low flows.

4.2.5 Hydrogeology

Groundwater regime in the Cooksville Creek watershed is divided into three parts: upper watershed, middle watershed, and lower watershed. The Eglinton Ave. W and Dundas St. act as two boundaries dividing the watershed into upper, middle and lower watershed. Total discharge of groundwater in the Cooksville Creek watershed is about 87 L/S, over 85% of which is contributed by middle and upper watershed. The large contribution by middle and upper watershed may be due to the upgradient movement of deep groundwater and the passive dewatering in headwater areas of the east tributary.

Recharge of groundwater has been affected dramatically by urbanization since urban development alters the natural hydrological cycle as a result of clearing of vegetation and paving of the ground surface (i.e. increasing impervious cover). Recharge rates across the watershed are presented in **Table 4.3**

Table 4.3 Physiography and Recharge in the Cooksville Creek Watershed (CVC, 2010)

Watershed component	Geological characteristics	Recharge rate
Upper watershed	Till plain underlain by continuous Halton Till	Moderate
Middle watershed	Till plain and shale plain	Low
Lower watershed	Iroquois Sand Plain with a few patches of outcropped bedrock and Halton Till	High

Comparing with recharge in un-urbanized areas, the recharge in the Cooksville Creek watershed has the following characteristics:

- The total amount of recharge is reduced greatly by pavement, buildings and anthropogenic consolidation of soils as a result of urbanization;
- The geographical distribution of recharge becomes more uneven since recharge is reduced almost to zero for most of paved and built-up areas;
- The recharge occurs mainly on public areas – parks and corridors (transportation, utilities, and creeks), natural areas and conservation areas.

4.2.6 Hydraulics

The Regulatory Storm for the Cooksville Creek watershed is the Regional (Hurricane Hazel) Storm except upstream of Highway 10 on the east branch where the 100 year storm governs. The Regulatory Floodplain along Cooksville Creek occupies a total area of approximately 150 ha and ranges in width from 20 to 300 m. The Regulatory floodplain above Burnamthorpe Road East is narrow in comparison to the floodplain below Dundas Street.

According to EWRG (2002), six (6) spill zones are located along Cooksville Creek. Spill zones are areas where flow may bypass a crossing and re-enter the watercourse further downstream or be diverted to another watershed. The spill zones are found at the following locations:

- CNR;
- Queen Elizabeth Way;
- Kirwin Avenue;
- Hurontario Street;
- Highway 403; and
- Rathburn Road East (East Branch)

4.2.7 Fluvial Geomorphology

Historical records of Cooksville Creek indicate that, prior to extensive urbanization and development, the creek exhibited a more meandering form associated with a channel in unconsolidated material and a more gradual slope. The drainage density (ratio of stream length to drainage area) of the basin in the 1950's was substantially higher than present, as the main channel benefited from numerous contributing tributaries; granted many of these tributaries has been modified due to agricultural practices.

Cooksville Creek in its present-day form is channelized over most of its length (92%) (**Table 4.4**) through a variety of methods and materials, including gabion baskets, concrete, rip-rap, armourstone and grass lining (**Figure 4.2**). The removal of low-order tributaries over time has resulted in a simplistic drainage network comprised essentially of two, first-order upstream branches and a second-order main channel.

Table 4.4 Summary of Channel Lining Materials (EWRG, 2002)

Channel Lining Material	Watercourse Length	% of Total Length
Gabion Baskets	3.5 km	24 %
Concrete	1.7 km	11 %
Natural (eroded)	1.2 km	8 %
Armourstone	2.4	16 %
Grass – Trapezoidal	6.4	41 %
Total	14.9 km	100 %

Figure 4.2 Channelized sections of Cooksville Creek (CVC, 2010)

The prevailing geomorphic condition of Cooksville Creek can be summarized as a watercourse that is actively adjusting in the form of widening and degradation (incision). These two processes have combined to create an over-sized cross-section which was necessitated by the need to accommodate urbanized peak flow events but, for most of the year, supports minimal baseflows. The two primary modes of channel adjustment have also resulted in the extensive failure of bank and bed protection throughout the creek due to undermining and outflanking.

4.2.8 Water quality

As surface runoff moves on impervious areas, it picks up and carries away natural and human-made pollutants, finally depositing them into lakes, rivers, wetlands, and ground waters. Urban stormwater runoff can include elevated levels of suspended solids, bacteria and nutrients from livestock, pet wastes and faulty septic systems, excess fertilizers, herbicides and insecticides from agricultural lands and residential areas, oil, grease and toxic chemicals and sodium and chloride from road salt.

Figure 4.3 shows an example of water quality issues in the Cooksville Creek watershed. Parameters of Concern (POCs) were identified on a watershed scale as indicators of water quality for the Cooksville Creek watershed. These POCs were identified for both surface water (instream) and stream sediments.

Surface water within Cooksville Creek has high levels of E coli and chloride. Water temperatures do not comply with the Provincial standards for cold water habitat. Under dry weather conditions, concentrations for nutrients and metals meet guidelines. However, wet weather concentrations/loadings are significantly high for nutrients and metals and esceeded guidelines.

Figure 4.3 Water quality issues within the Cooksville Creek watershed (CVC, 2010)

The following trends of the groundwater quality can be found in the watershed (CVC, 2010)

- Groundwater is very hard and increases in hardness down gradient because of the long flow distance.
- The groundwater throughout the watershed has high concentration of sodium and chloride due to the intensive application of road salt and winter de-icers.
- The concentration of sulfate is relatively high. The high concentration of sulphate may be related to the pyrites in shale formation.
- In general, the groundwater in the watershed is not suitable for drinking purpose, but it can be used for irrigation and other commercial purposes.
- Groundwater contamination could include sources such as road salt, spills, landfill leakage, contaminated sites, leakage from sanitary sewers and other human activities.
- Groundwater quality should be investigated further. More sampling and experience are needed to get statistically real results from outfall sampling.
- All parameters of concern are within permissible limits except for Un-Ionized Ammonia and Dissolved Oxygen, where some samples showed higher and lower concentrations, respectively.

4.3 Municipal infrastructure

There are three types of drainage systems in the Cooksville Creek watershed (**Figure 4.4**). They are: Minor Drainage System such as storm sewers, ditches and swales (Figure 4.4a), Major Drainage System such as the Cooksville Creek and related overland flow paths (Figure 4.4b), and Stormwater Management (SWM) facilities such as wet ponds, dry ponds and wetlands (Figure 4.4c).

Traditionally, drainage infrastructure in the Cooksville Creek watershed was designed to quickly and efficiently remove flows to safely control and convey stormwater without flooding effects. As the impacts of improper management of stormwater runoff became more evident, stormwater management facilities such as detention basins were constructed to store the stormwater runoff and slowly release it to the receiving waterways.

There are three stormwater management facilities within the Cooksville Creek watershed. They are:

- **Water quantity on-line pond on Bristol Road**: Constructed in the eighties. Located north of Bristol Road West and west of Hurontario Street. The pond is intended to provide downstream protection up to the 100-year storm eventfor the 600ha upstream portion of the watershed (CVC, 2010);
- **Water quantity pond on Burnhamthorpe Road**: Constructed in 1999 to provide water quantity control for Square One. The volume provided within the pond is 77 m^3;
- **MTO Pond on Highway 403.**

Figure 4.4c shows one of these facilities: MTO pond on Highway 403, which is located in the headwaters of Cooksville Creek East Tributary. The facility was constructed to provide water quantity and quality control to the flows from the median and northeast bound lanes of Highway 403 between Cawthra Road South and Central Parkway Boulevard. The facility controls and releases flows at pre-development levels for the 2 year through 100 year storm events. The active storage volume provided within the pond is 2,031 m^3, which control flows from a tributary area of 24.0 ha.

Traditional stormwater management systems, including storm sewers and detention ponds fail to effectively address flooding and other environmental issues. During the last twenty years, it has been proven that innovative stormwater management alternatives including source control (measures on private property), conveyance control (measures within road right of ways) together with end of pipe measures (dry ponds, wet ponds, wetland and subsurface facilities) applied sequentially can replace traditional measures.

Figure 4.4 Examples of drainage systems in the Cooksville Creek watershed

4.4 Socio-Economic Environment

Written Archaeological evidence suggests that Native peoples had been attracted to the Cooksville Creek watershed and greater Credit River valley for thousands of years. Iroquoian and Algonquian and later Ojibiway inhabited the area as rivers, creeks, forested areas and Lake Ontario provided ample opportunities for fishing and hunting.

European settlement of the Cooksville Creek watershed and greater Credit River watershed began with the first and second purchases of the Mississauga tract by the British government (an area extending from Burlington to the Etobicoke River) in 1805. Several small villages and residential areas were established in the 19th century to support the surrounding farms with supplies, communication, trade and processing capabilities. Within the Cooksville Creek watershed were several villages, hamlets and residential districts (CVC, 2010). Lakeview, Mineola, Cooksville, and Dixie are only a few areas found within the Cooksville watershed.

After World War II, agricultural lands that had previously characterized the Cooksville Creek watershed, gave way gradually to residential, commercial and industrial development. The rise of the automobile, improvements of roads and creation of the highway system allowed people to live further away from city centers like Toronto where they worked. Soon the villages of Cooksville and Dixie gave way to the development of the City of Mississauga. The increased development of the Cooksville Creek watershed led to major modifications to the Cooksville creek watercourse.

4.4.1 Land use

The Cookville Creek watershed is an urban watershed. The distribution of land use in the watershed is approximately 60% residential, 34% industrial/commercial and 6% open space (CVC, 2010). **Table 4.5** shows a breakdown of land uses.

Table 4.5 Land use summary (CVC, 2010)

Land Use	Percentage
Residential • Low Density • Medium Density • High Density	 37% 5% 4.5%
Industrial/Commercial	23 %
Community Parks/Open Space	6.0 %
Institutional	5.0 %
Natural Areas	9.5%
Agriculture	4.0%
Roads	6.0%

4.4.2 Transportation / Utility Corridors

The Cooksville Creek watershed contains major transportation corridors that run throughout the watershed and provide major economic and social benefits. These transportation corridors include:

- Road corridors: including Highway 401 and Highway 403 and other major roads that constitute a large percentage of the imperviousness of the watershed. Hwy 401 is located in the headwaters of Cooksville Creek, and Hwy 403 is located in the centre part of the watershed. Generally speaking, most of flood damages are located south of Hwy 403 where many buildings are located within the regulatory floodplain.

Many road crossings within the watershed constrain the flow of Cooksville Creek and negatively affect the conveyance of water, increase backwater and flooding potential, and change velocity and erosion thresholds along the Creek.

- Rail corridors: Canadian National Railway (CNR), and Canadian Pacific Railway (CPR)

Utility corridors cover a very small area in the Cooksville Creek watershed. They range from 30 to 100 meters wide with turf and meadow vegetative cover. Utilities include underground dry utilities (e.g., gas) and overhead wires. In some areas, tributaries to Cooksville Creek run along or through the corridors. Therefore, utility corridors represent a great opportunity for ecological restoration, and maintenance of the natural hydrologic regime within the watershed. Utility corridors within the watershed include the following:

- Utility Corridor 1 – North of the QEW
- Utility Corridor 2 – North of Queensway Boulevard
- Utility Corridor 3 – North of Highway 403

Figure 4.5 Utility corridors within the Cooksville Creek watershed, from Left to Right: Utility corridor 1, Utility corridor 2, and Utility corridor 3

5.0 EVALUATION OF ALTERNATIVES

5.1 General

This chapter provides a general description of alternatives evaluated in order to address solutions for key issues described in Section 2.1 and meet the study objectives as identified in Section 1.1. For the purpose of screening the alternative solutions, the evaluation criteria are presented. Finally, the rationale for selecting the preferred solution is discussed.

5.2 Long list of alternatives

For the purpose of addressing the study objectives as outlined in Section 1.1, a long list of alternative solutions are presented below. The alternatives listed are mainly concerned with flood mitigation within the Cooksville Creek watershed. Other environmental benefits would result from implementing the long list of alternatives including improving water quality and stream health and stability.

The long list of alternatives is divided into two categories: Traditional and non-traditional. Traditional alternatives can be defined as measures that are designed and implemented based on engineering-based flood mitigation measures that would increase the conveying capacity of watercourses and crossings. Non-traditional alternatives are mostly stormwater management measures that encourage the use of the resources of the watershed as a whole by promoting stormwater storage, infiltration and other innovative measures to decrease surface runoff at the watershed scale.

<u>Traditional alternatives</u>

- Watercourse capacity upgrade: increasing the capacity of the existing watercourse may reduce flood levels.
- Crossing capacity upgrade: increasing the capacity of existing culverts or bridges may reduce water levels.
- Dykes/Berms: dykes or berms are built adjacent to dwellings in order to contain flows within the floodplain.
- Flood proofing: Landowners can floodproof buildings by sealing or filling in openings which are susceptible.
- Land acquisition: Flood susceptible properties could be purchased by the City or Credit Valley Conservation.

<u>Non-Traditional alternatives</u>

- Storage in Upstream locations: storage in upstream lands within parks or vacant properties could be used to reduce flood levels in Cooksville Creek.

- Source control measures: implemented on private property, include roof downspout disconnection, use of rain barrels, pervious driveways and rain gardens.
- In-channel storage: storage within Cooksville Creek could be used to reduce flood levels.
- Conveyance control measures: implemented within the municipal right-of-way include bioretention units, or perforated pipes. The measures encourage infiltration or evapotranspiration, thereby reducing runoff and flood levels.
- Tunnel: construction of a tunnel, which would divert flows above levels which cause flooding could be considered.

The evaluation of the long list of alternatives including the traditional and the non-traditional alternatives mentioned above was carried out at two levels:

- First evaluation level: provides a general description of each potential alternative and evaluates each alternative based on the following categories of criteria:
    - Natural environment
    - Economic
    - Social/Cultural
    - Implementation
- Second evaluation level: carries out a technical assessment of the alternatives which have been brought forward in order to establish a practical plan.

5.3 Evaluation Criteria

The Environmental Assessment Act and the Municipal Class Environmental Assessment (Class EA) document require a systematic evaluation of alternatives in terms of their advantages and disadvantages. The evaluation of alternatives for this study involves assessing alternative solutions based on sets of criteria that are founded on the objectives and the rationale of the study, in addition to considerations of the Environmental Assessment process. The evaluation criteria considered in assessing each alternative are shown in **Tables 5.1 to 5.4**, and they include a series of evaluation criteria consisting of Natural Environment, Social/ Cultural, Economic and Implementation criteria. Each alternative from the long list (Section 5.2) was assessed based on these categories of criteria consistent with the Environmental Assessment process.

Table 5.1 Natural Environment Evaluation Criteria

Natural environment evaluation criteria	Description of criteria
Potential to reduce riverine flooding	Potential to reduce flooding of properties along Cooksville Creek floodplain
Potential to reduce erosion	Potential to reduce erosion within Cooksville Creek
Potential to improve water quality	Potential to improve water quality based on existing water quality conditions
Potential to improve aquatic habitat	Potential to improve aquatic habitat by improving baseflows or stream habitat

Table 5.2 Economic Evaluation Criteria

Economic evaluation criteria	Description of criteria
Construction costs	The relative cost of the alternative
Operation and Maintenance	The relative cost of operating and maintaining the alternative based on factors such as overall maintenance frequency and intensity, equipment needs and future permit requirement
Infrastructure protection	Potential to protect existing or proposed infrastructure including storm outfalls, sanitary sewers, pedestrian bridges, etc.

Table 5.3 Social/Cultural Evaluation Criteria

Social/Cultural evaluation criteria	Description of criteria
Aesthetics/Recreation	Potential for the alternative to be an asset to the community by integrating the alternative into existing site activities (walking, jogging, park usage) and/or improve aesthetics; or to impact existing park usage or detract from aesthetics
Compatibility with adjacent land use	There are potential impacts associated with construction of retrofit facilities, or future maintenance particularly with respect to adjacent land use Access/egress also needs to be considered
Community disruption	The potential of the alternative to disrupt the community, more specifically given the surrounding land use – business activities during, or after the construction process
Public/User acceptance	Public/user acceptability of proposed alternative including construction impacts, property value, life style changes, noise/odour issues

Table 5.4 Implmentation Evaluation Criteria

Implementation Evaluation criteria	Description of criteria
Timing to implementation	Length of time required to implement the proposed alternative
Technical feasibility	The feasibility of implementing the proposed alternative

5.4 Selection of preferred alternatives

In order to evaluate alternatives and compare them in a quantitative manner, a ranking system is proposed that is based on five (5) measures of effectiveness and shaded circles that represent effectiveness. Effectiveness of each alternative ranges from least effective using an unshaded circle, to most effective, using a full shaded circle. Quarter, half and three quarter shaded circles were also used where alternatives respond only slightly or moderately well to criterion, respectively. The alternatives which received a favorable rating (i.e. most effective) were brought forward and forms the basis for the preferred strategy.

Tables 5.5 and 5.6 represent the evaluation matrices for traditional alternatives and non-traditional alternatives, respectively. Each alternative was evaluated based on effectiveness in addressing the evaluation criteria as explained in **Tables 5.1, 5.2, 5.3 and 5.4**, and a decision to bring it forward or not was taken. Chapter 6 describes the Recommended Plan, which is a collection of alternatives that have received the highest mark in the evaluation exercise.

Table 5.5 Evaluation matrix for Traditional alternatives

Evaluation Criteria	Watercourse Capacity Upgrade	Crossing Capacity Upgrade	Dykes / Berms	Flood Proofing	Land Acquisition
Natural Environment	• Good potential to reduce riverine flooding	• Good potential to reduce riverine flooding	• Moderate potential to reduce riverine flooding	• Limited potential to reduce riverine flooding	• Limited potential to reduce riverine flooding
Economic	• Moderate construction cost • Low operation and maintenance cost	• Moderate construction cost • Low operation and maintenance cost	• Low to moderate construction cost • Moderate to high operation and maintenance cost	• Low to moderate construction cost • Moderate to high operation and maintenance cost	• Moderate to high construction cost • Low operation and maintenance cost
Social / Cultural	• Generally accepted by public and agencies • Limited disruption during construction • Compatible with adjacent land uses	• Generally accepted by public and agencies • Limited disruption during construction • Compatible with adjacent land uses	• Generally accepted by agencies, may be issue if constructed on private property • Limited disruption during construction • Compatibility with adjacent land uses to be assessed on site by site basis	• Generally accepted by agencies • Acceptance by homeowners site specific	• Last resort alternative by agencies • Generally does not meet with landowner approval
Technical	• Technically feasible • Short implementation period	• Technically feasible • Short implementation period	• Technically feasible • Moderate implementation period	• Feasibility dependent upon site conditions and flooding extent • Short implementation period	• Technically feasible • Moderate implementation period
Overall Alternative Rank					
Comment	**Brought forward**	**Brought forward**	**Brought forward, but limited to public lands or with homeowner consent**	**Not brought forward, but to be implemented independently by homeowner**	**Not brought forward**

Most Preferred  Least Preferred

Table 5.6 Evaluation matrix for Non-Traditional alternatives

Evaluation Criteria	Storage in upstream locations	In-channel storage	Source control measures	Conveyance control measures	Tunnel
Natural environment	• Good potential to reduce riverine flooding, limited for basement flooding • Good potential for reducing erosion, improving water quality and aquatics	• Moderate potential to reduce riverine flooding • Moderate potential to reduce erosion	• Good potential to reduce riverine flooding, limited for basement flooding • Good potential for reducing erosion, improving water quality and aquatics	• Good potential to reduce riverine flooding, limited for basement flooding • Good potential for reducing erosion, improving water quality and aquatics	• Good potential to reduce riverine flooding
Economic	• Moderate construction cost • Moderate operation and maintenance cost • Moderate benefit in protecting existing infrastructure within floodplain	• Moderate construction cost • Moderate operation and maintenance cost	• Low construction cost • Low to moderate operation and maintenance cost • Moderate benefit in protecting existing infrastructure within floodplain	• Moderate construction cost • Moderate operation and maintenance cost • Moderate benefit in protecting existing infrastructure within floodplain	• High construction cost • High operation and maintenance cost
Social/Cultural	• Generally accepted by public agencies • Low to moderate community disruption • Potential to be asset to community	• Generally accepted by public agencies • Low to moderate community disruption • Potential to be asset to community	• Generally accepted by public agencies • Low community disruption • Potential to be asset to community	• Generally accepted by agencies • Low community disruption • Potential to be asset to community	• Compatibility with adjacent land uses unknown • Questionable agency acceptance • Considerable community disruption
Technical	• Technically feasible • Short to moderate implementation period	• Feasibility dependent upon site condition • Short to moderate implementation period	• Technically feasible • Short implementation period	• Technically feasible • Short to moderate implementation period	• Feasibility dependent upon site condition • Long implementation period
Overall alternative rank	●	◕	●	●	○
Comment	**Brought forward**	**Brought forward**	**Brought forward, but to be implemented as part of City Wide Water Quality Study Implementation**	**Brought forward, but to be implemented as part of City Wide Water Quality Study Implementation**	**Not brought forward**

6.0 RECOMMENDED PLAN

Chapter 5 presented and described a long list of potential alternatives. It also presented an evaluation criteria that was used to identify the most and least effective alternatives to undertake in order to address four (4) sets of criteria, namely Natural Environment, Social/Cultural, Economic and Implementation considerations. This chapter presents the Recommended Plan, which is a group of preferred alternatives within the following framework:

- Existing conditions: reviews hydrologic and hydraulic considerations that define existing flooding issues along Cooksville Creek. The review is mostly based on the EWRG (2002) report which is a comprehensive flood remediation study that included hydrologic and hydraulic modeling of Cooksville Creek. The report also proposed several traditional measures to mitigate flood damagesfor the Regulatory Storm;
- Technical assessment of the Recommended Plan.

6.1 Existing conditions

Previous studies identified actual and potential flooding issues within the Cooksville Creek watershed. The studies showed that development before 1975 did not consider floodplain management in areas that are generally located south of Hwy 403. Development after 1975 is generally outside the Regulatory floodplain (generally north of Hwy 403).

Previous hydrologic analysis (EWRG, 2002) showed that the 100-year flows along Cooksville Creek ranges between 80 m^3/s at the Creek headwaters (i.e. Matheson Ave, West) to 210 m^3/s at Lakeshore Avenue located at the mouth of Cooksville Creek as shown in **Table 6.1** and **Figure 6.1**.

A comprehensive evaluation of the performance of road crossings (culverts, bridges, etc) was carried out by EWRG (2002). **Table 6.2** shows the capacity of road crossings along Cooksville Creek, flow events with frequencies that range from 2-year to Regional flow, and the impact of these flows on road crossings and buildings in terms of overtopping/bypassing or flooding, respectively. **Table 6.2** shows that channel and crossing capacity of road crossings is less than 10 year flow in many locations (e.g. Queen Elizabeth Way and Camilla Road). Many of the crossings would be overtopped or bypassed by flows that range from the 2-year storm to the Regional storm. For example, Paisley Boulevard East and King Street East are overtopped by all flows exceeding the 2-year storm flow.